Test, redesign and construction of a new water cooling pump slab bench

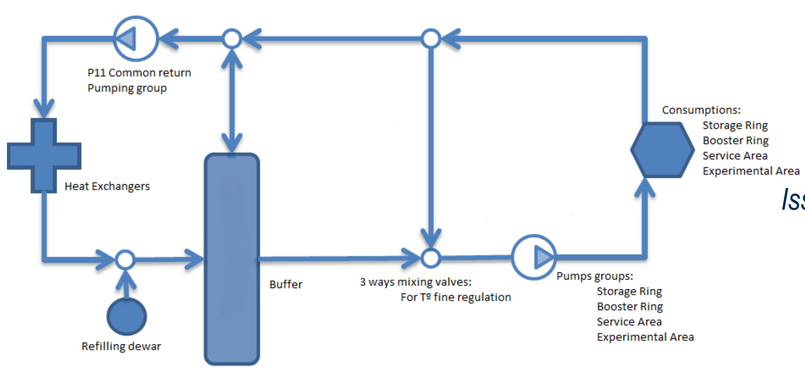
Carles Colldelram[1], Marcos Quispe[1], David Carles[1], Joan Casas[1], Juan José Manotas[1], Llibert Ribó[1], Gabriel Peña1, Lluis Miralles[2]

1. CELLS-ALBA, 08290 Cerdanyola del Vallès, Spain.
2. CERN, Geneva, Switzerland

Abstract

The water cooling system at ALBA is divided in two main sub-systems. First the consumption side which consist of four independent circuits, each one with an independent dedicated pumping unit: Storage Ring, Booster, Experimental Area and Service Area. The second one is the production side where all four circuits are collected into a common return circuit where there are mainly the heat exchangers and a buffer tank, ending at the four circuits aspiration manifold. Consequently the return circuit to the production side is a huge piping which needs a pump powered by an asynchronous motor of about 75kW. During the facility start up the maintenance team realized about too much recurrent unexpected reparations of this common return pumping unit. ALBA pump bench standard design consists of a twin pump unit mounted on a single bench. A simulation with FEA analysis tools and field measurements on the bench, by means of accelerometers, has shine out the overlap of the two main motor harmonic excitations on the two first resonance modes of the mechanical bench at about 50 Hz and 75 Hz, reaching up to 4 mm amplitude. A new design of the bench has been proposed, aimed to push the resonance modes to higher frequencies far away of the powerful harmonic excitations increasing in turn, the rigidity and therefore reducing the deformation amplitudes. Taking advantage of the need for this new design, also the mechanical interfaces have been improved. A new slab bench prototype has been constructed and tested, reaching up resonances close to 200 Hz and it is ready for installation during next shut down. By means of this new development, pumping benches design criteria is clarified for the rest of pumps. The new design will be applied to all services: water cooling as well as air conditioning which are still based on the initial ALBA standard approach..

Precedents



Cooling System:

- *Four impulsion independent circuits*
  - *Storage Ring*
  - *Booster*
  - *Service Area*
  - *Experimental Area*
- *One single return*
  - *Motor pump: 75 kW*

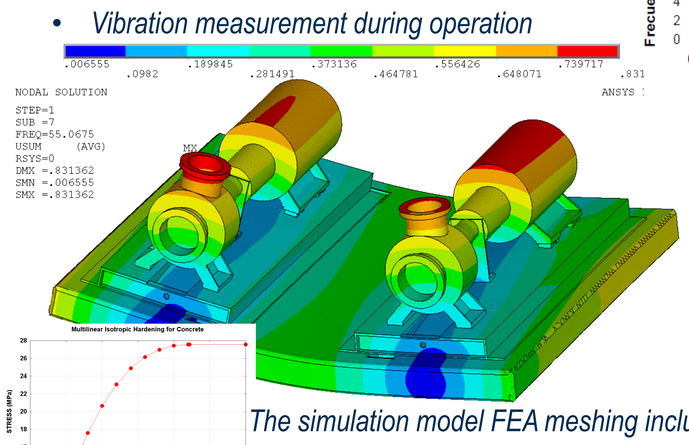
Issue:

- *The reparation periodicity on the motor pump mechanism is to much higher than expected*
- *As there are two pumps installed on the same slab (the working one and it redundancy) the working one damages the resting one*

Diagnose & Simulation

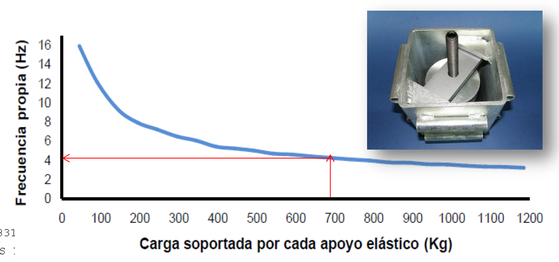
In order to diagnose the problem two action were taken:

- *Model & simulate the concrete slab*
- *Vibration measurement during operation*



The simulation model FEA meshing includes:

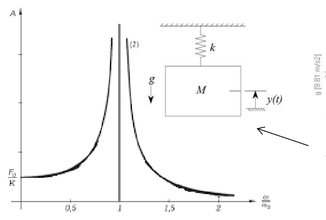
- *The steel frame model as beam element*
- *The anisotropy of the concrete*

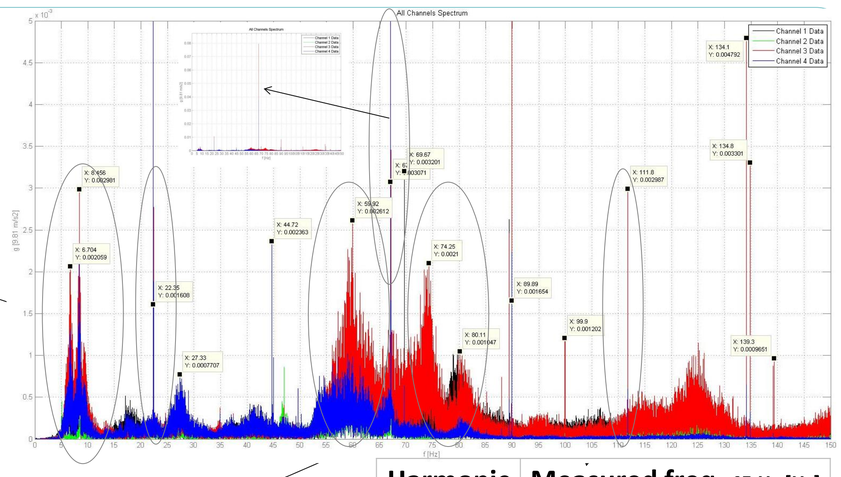


Resonance modes summary

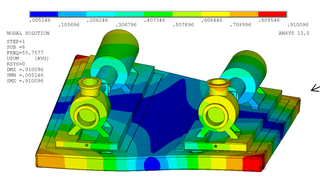
Mode	Simulated [Hz]	Measured [Hz]
f_0	4	8,45
f_1	55,1	59,92
f_2	55,8	74,25
f_3	127,5	125,1
f_4	128,8	129,1

Vibration Isolation pads resonance (Slab as a solid rigid): 6-8 Hz





Slab resonance modes



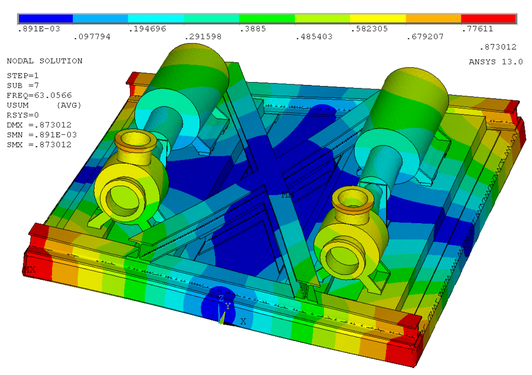
Harmonic	Measured freq. 45 Hz [Hz]
h_1	22,36 (25 Hz)
h_2	44,72 (50 Hz)
h_3	***67,07*** (75 Hz)
h_4	89,43(100 Hz)
h_5	111,8 (125 Hz)

Motor excitation harmonics: Frequency Driver: 45 Hz (50 Hz).

Design

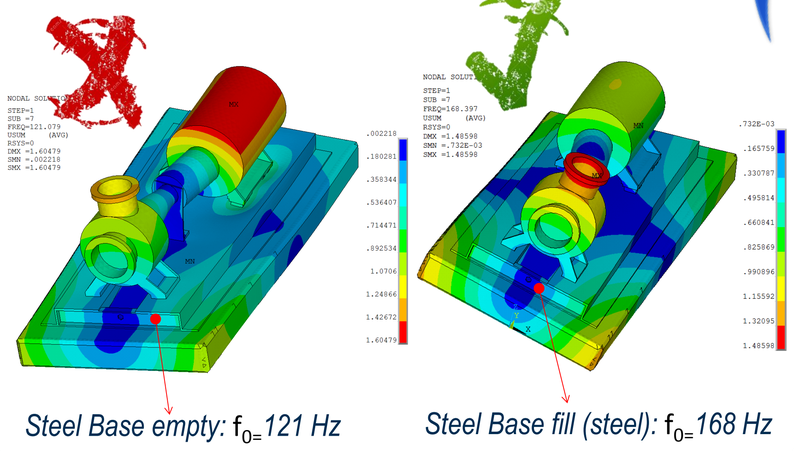
Option rigidizing the current slab:

- *The best solution found the firsts resonance modes are at 63 and 70 Hz. With cross reinforcing steel beams*
  - *This is not valid solution as the resonance is moved to the main motor excitation (75 Hz) at Frequency Driver set at 50 Hz.*



Splitting in two individual slabs and optimizing

- *Due the pipes routing installation configuration it is not possible to increase the total height of the slab*
- *The steel base where the motor is mounted is empty in order to optimize the behavior in the FEA this frame is fill it up meshing with steal.*

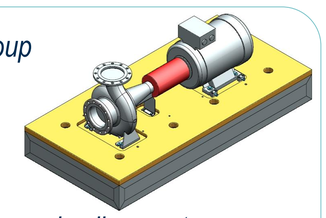


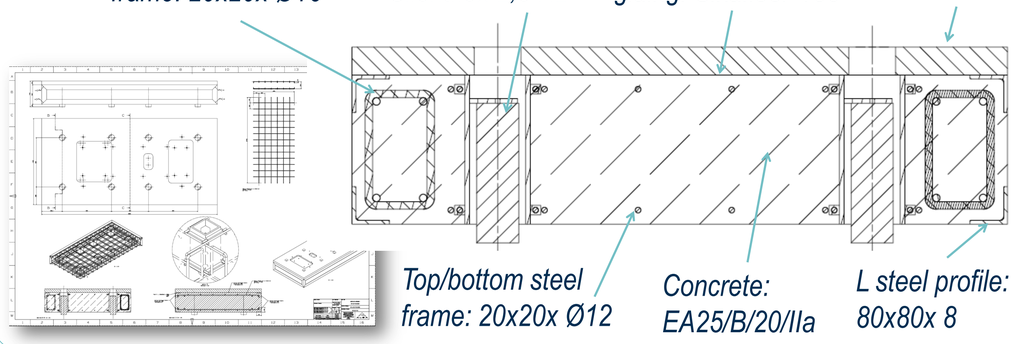
Steel Base empty: $f_{0=}$*121 Hz*

Steel Base fill (steel): $f_{0=}$*168 Hz*

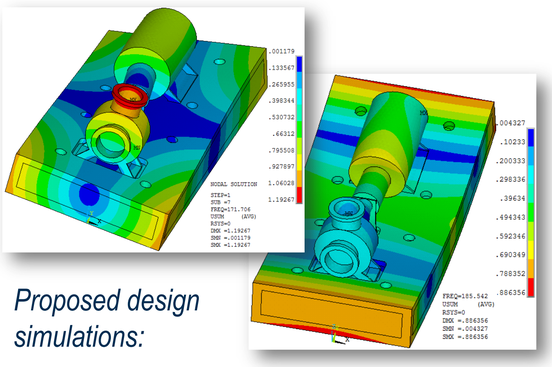
Proposed Design

1. *Split the slab in two independent one for each pumping group*
2. *The slab is composed by:*
   - *Concrete thick base*
   - *Steel base plate on tope for the motor & pump:*
     - *Stiffer*
     - *Good mechanical flat reference for better motor-pump axis alignment*





Construction & tests

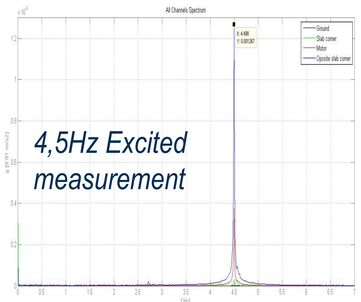


Proposed design simulations:

Mode	Simulated [Hz]
f_0	2,5
f_1	171,7
f_2	185,5

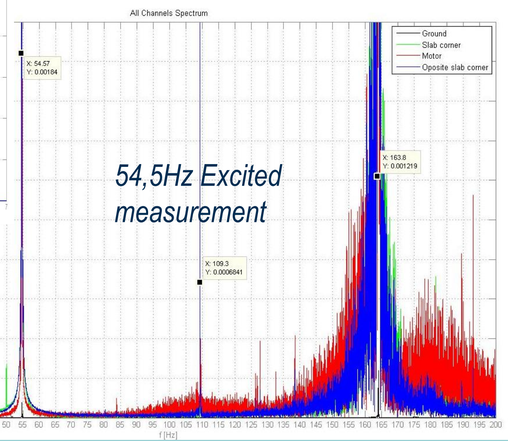
Construction

Tests



4,5Hz Excited measurement

Excitation scan measurements
From 0 to 60 Hz



54,5Hz Excited measurement

Isolation ratio:

$$\frac{Ground\ acc.}{Resonance\ acc.} = 610$$

Mode	Sim. [Hz]	Measd[Hz]
f_0	2,5	4,45
f_1	171,7	164
f_2	185,5	176,4 ?

Conclusions:

- *The slabs must be designed as thick as possible.*
- *The dimensions of the slab must be as close as posible as the motor-pump system dimensions*
- *A single pump per slab bench: no multipumps slabs*